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FORM PTO-1390 (Modified) (REV 11-2000) U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371

ATTORNEY'S DOCKET NUMBER: **10543-028**

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INTERNATIONAL APPLICATION NO	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED
PCT/EP00/01657	**28 February 2000**	**04 March 1999 & 09 November 1999**

TITLE OF INVENTION

METHOD FOR CONTROLLING A VEHICLE

APPLICANT(S) FOR DO/EO/US

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Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U S C 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U S C 371
3. ☐ This is an express request to begin national examination procedures (35 U.S.C 371(f)). The submission must include items (5), (6), (9) and (24) indicated below.
4. ☐ The US has been elected by the expiration of 19 months from the priority date (Article 31).
5. ☒ A copy of the International Application as filed (35 U.S.C 371 (c) (2))
   a. ☐ is attached hereto (required only if not communicated by the International Bureau)
   b. ☒ has been communicated by the International Bureau.
   c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☒ An English language translation of the International Application as filed (35 U.S C. 371(c)(2)).
   a. ☒ is attached hereto.
   b. ☐ has been previously submitted under 35 U.S.C. 154(d)(4)
7. ☐ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371 (c)(3))
   a. ☐ are attached hereto (required only if not communicated by the International Bureau).
   b. ☐ have been communicated by the International Bureau.
   c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
   d. ☐ have not been made and will not be made.
8. ☐ An English language translation of the amendments to the claims under PCT Article 19 (35 U S.C 371(c)(3))
9. ☐ An oath or declaration of the inventor(s) (35 U.S.C 371 (c)(4)).
10. ☐ An English language translation of the annexes of the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371 (c)(5)).
11. ☒ A copy of the International Preliminary Examination Report (PCT/IPEA/409).
12. ☒ A copy of the International Search Report (PCT/ISA/210).

Items 13 to 20 below concern document(s) or information included:

13. ☐ An Information Disclosure Statement under 37 CFR 1.97 and 1 98.
14. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3 28 and 3.31 is included.
15. ☐ A **FIRST** preliminary amendment.
16. ☐ A **SECOND** or **SUBSEQUENT** preliminary amendment.
17. ☐ A substitute specification.
18. ☐ A change of power of attorney and/or address letter.
19. ☐ A computer-readable form of the sequence listing in accordance with PCT Rule 13ter.2 and 35 U.S C. 1.821 - 1.825.
20. ☐ A second copy of the published international application under 35 U.S.C. 154(d)(4)
21. ☐ A second copy of the English language translation of the international application under 35 U S.C. 154(d)(4)
22. ☒ Certificate of Mailing by Express Mail
23. ☐ Other items or information:

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U.S. APPLICATION NO. (IF KNOWN, SEE 37 CFR 1.5)	INTERNATIONAL APPLICATION NO.	ATTORNEY'S DOCKET NUMBER
09/914807	PCT/EP00/01657	10543-028

24. The following fees are submitted:.

BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)) :

		CALCULATIONS PTO USE ONLY
☐	Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO	$1000.00
☒	International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO	$860.00
☐	International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO	$710.00
☐	International preliminary examination fee (37 CFR 1.482) paid to USPTO but all claims did not satisfy provisions of PCT Article 33(1)-(4)	$690.00
☐	International preliminary examination fee (37 CFR 1.482) paid to USPTO and all claims satisfied provisions of PCT Article 33(1)-(4)	$100.00

ENTER APPROPRIATE BASIC FEE AMOUNT =	**$860.00**	
Surcharge of **$130.00** for furnishing the oath or declaration later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1 492 (e))	**$0.00**	

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE		
Total claims	18 - 20 =	0	x $18.00	**$0.00**	
Independent claims	2 - 3 =	0	x $80 00	**$0.00**	
Multiple Dependent Claims **(check if applicable)**.			☒	**$270.00**	
TOTAL OF ABOVE CALCULATIONS =				**$1,130.00**	
☐ Applicant claims small entity status. (See 37 CFR 1.27). The fees indicated above are reduced by 1/2.				**$0.00**	
SUBTOTAL =				**$1,130.00**	
Processing fee of **$130.00** for furnishing the English translation later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492 (f)). +				**$0.00**	
TOTAL NATIONAL FEE =				**$1,130.00**	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31) **(check if applicable).** ☐				**$0.00**	
TOTAL FEES ENCLOSED =				**$1,130.00**	
				Amount to be: refunded	$
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a. ☒ A check in the amount of **$1,130.00** to cover the above fees is enclosed

b. ☐ Please charge my Deposit Account No _____ in the amount of _____ to cover the above fees. A duplicate copy of this sheet is enclosed

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d. ☐ Fees are to be charged to a credit card. **WARNING:** Information on this form may become public. **Credit card information should not be included on this form.** Provide credit card information and authorization on PTO-2038.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:

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8-30-01
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3/PRTS

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JC03 Rec'd PCT/PTO 30 AUG 2001

Method for Controlling a Motor Vehicle

The present invention relates to a method for controlling a vehicle, in particular a traction-slip control system, as well as a method and circuit arrangement for detecting a diagonal axle twist in a vehicle with all-wheel drive.

Vehicle control systems which reduce the wheel slip to a value appropriate for ensuring traction and driving stability by building up brake pressure on the overspeeding drive wheels and applying a stronger drive torque to the wheels with tire contact are known from the prior art. These systems are available both for two-wheel drive and all-wheel drive vehicles. These vehicle control systems are called traction-slip control systems (TCS), or also „Electronic Differential Lock„, „Automatic Stability Control„ and „Traction Control System„.

Two designs have to be differentiated with respect to traction-slip control systems: traction-slip control and brake traction-slip control or brake traction-control systems. The first, i.e. traction-slip control system, additionally throttles the engine torque in certain situations in order to keep the load on the brakes as low as possible. The brake traction-slip control systems become effective only through automatic braking intervention. In the following, „TCS„ refers to all feasible traction-slip control systems, i.e. those with and without intervention in the engine management.

Traction-slip control systems basically are configured for primarily level ground and road usage characterized by an at least approximately identical friction coefficient on both sides.

When an all-wheel drive vehicle without axle differential lock drives over a diagonal furrow, causing the diagonally opposite front wheel and rear wheel to lose contact to the ground, these two wheels spin and so prevent any drive torque from being applied to the two wheels touching the ground (the two opposite wheels along the other vehicle diagonal). Since the vehicle is twisted considerably, this situation should be overcome as quickly as possible. For this purpose, strong tractive power is necessary to move the vehicle. An uphill road or an abrupt obstacle, for example a stone, lying in front of one or several wheels makes the situation even more difficult.

In this case, sufficient traction can only be obtained with the help of a differential lock, because practical experience has shown that the measures realized in previous TCS systems have not sufficed since usually exceedingly large slip values at the spinning wheels are tolerated. The brake pressure on the relieved wheels is not maintained in the brakes long enough and, hence, a locking effect comparable to that of a differential lock is not achieved.

The driven wheels of a vehicle diagonal are alternately subject to traction slip and the engine torque oscillates between the wheels involved depending on the current wheel load, brake pressure and engine torque. The pressure modulation in the driven wheels follows the traction slip. A stationary state is not reached. The vehicle becomes stuck.

The problem is to be illustrated on the basis of the following description.

The power consumed PB in a wheel rotating at a constant speed U/t and constant brake pressure FB is:

$$PB = FB * vB = FB * 2 * \pi * r_{eff} * U/t \quad (1)$$

Here r_{eff} is the effective wheel radius, on which the brake force acts. U/t is to be stated as wheel rotations per second.

Taking as an example the assumption that the left front wheel and right rear wheel spin on a diagonal furrow and are braked by the traction control, the following equations can be derived for the power consumed:

$$PB1 = FB1 * vB1 = FB1 * 2 * \pi * r_{eff1} * U1/t \quad (2.1)$$

$$PB3 = FB3 * vB3 = FB3 * 2 * \pi * r_{eff3} * U3/t \quad (2.2)$$

The wheel indices are selected clockwise:
1 = left front wheel
2 = right front wheel
3 = left rear wheel
4 = right rear wheel

Assuming that the brakes have approximately the same dimensions on the wheels and the speed of the spinning wheels as well as the brake force also are equal, the sum performance can be simplified as follows:

$$PBges = FB * 4 * \pi * r_{eff} * U/t \quad (3)$$

The total braking torque MBges applied by the wheels, which acts on the other wheels - via the axle differentials or center differential - as total drive torque MAges comes to:

$$MAges_{spinning\ wheels} = MAges_{(tractive\ wheels)} = FB * 2\ r_{eff} \quad (4)$$

Equation (3) makes evident that the entire engine power can be easily consumed with a sufficiently high speed U/t of the spinning wheels and medium brake force FB. When the brake forces FB are too small, only a negligible drive torque is provided according to equation (4). However, in extreme off-

road driving situations, especially in the event of diagonal twist, a high peak torque is required at least for a short time to free the motor vehicle from the difficult situation.

This situation occurs relatively frequently on bumpy ground, since strong unevenness at first always causes one wheel to lose contact with the ground and tilting along a diagonal, which does not include the wheel that is off the ground. The wheel located diagonally to the wheel off the ground also will lose its tire contact force, either completely or partially, depending on the direction of tilt and inclined position of the motor vehicle.

Therefore, it is the object of the present invention to improve a method for controlling a motor vehicle, in particular for driving situations on bumpy ground. Moreover, a partial object provides a method and a circuit arrangement, which definitely detect a diagonal axle twist, in particular one caused by a driving situation on bumpy ground with diagonal furrows or abrupt obstacles.

The object according to the invention is solved by a method for controlling a motor vehicle, in particular a traction-slip control system (TCS), which is characterized in that a diagonal axle twist is detected and evaluated as a regulating variable.

According to the method proposed by the present invention for controlling a motor vehicle, the situation of a diagonal axle twist is determined first. Then the state of the axle twist is evaluated as a regulating variable for the vehicle control. According to this regulating variable, systematic intervention, in particular of the vehicle control system, in, for example, the brake control, engine management, transmission function and/or function of differential locks can be initiated.

According to the present invention, the effect of locking partially or completely a center, front axle and/or rear axle differential is achieved with means of the vehicle control system, especially by measuring and/or modulating the brake pressure in the wheel brakes of the controlled wheels, and/or a center, front axle and/or rear axle differential is locked partially or completely with the help of a differential lock, if available.

At first the method necessarily demands that the need for a diagonally locked state be recognized and that such a diagonally locked state subsequently be achieved with means of the vehicle control system, preferably by controlling the brakes with the traction-slip control, wherein one or several available differential locks, for example a center differential lock, may additionally be activated. However, it is also possible to activate one or several available differential locks alternatively to the brake control. Furthermore, according to the present invention, intervention in the engine management is to occur in addition to brake intervention, for example by means of such control elements as throttle valve or ignition.

The present invention provides that, following the detection of the diagonal axle twist, a medium brake pressure level be set at the wheel brakes of the controlled wheels with a minimal drive slip corresponding to the required traction and that this be maintained for a certain period of time.

Sufficient traction is obtatined in this case by maintaining the brake pressure at the relieved wheels for a period of time to achieve a locking effect comparable to that of a differential lock until the situation of the diagonal axle twist has been overcome. In this way the above-mentioned periodic oscillation of the engine torque between the wheels of a vehicle diagonal will be safely avoided, after the axle twist

was detected by the method according to the invention, by preventing any lagging of the brake pressure. The locked state of the differentials or the comparable effect of a locked state preferably is maintained for a period of time that is sufficient for moving the vehicle over the obstacle. The speed U/t of the spinning wheels is reduced by stronger braking. Thus, there is a significant increase in comfort, scraping of the wheels is basically prevented and the engine speed remains constant and relatively low. In addition, tire wear is minimized.

According to the invention, the wheels concerned are controlled with relatively low slip values, preferably less than 30 km/h, so that higher pressure levels are set at the wheel brakes. For this purpose, the spinning wheels are braked down to traction slip values close to zero (0) in extreme cases.

Increased build-up and delayed reduction of the brake pressure can be achieved in an advantageous manner by changing the pressure build-up and reduction gradients. The pressure modulation also can be changed by building up pressure quicker and reducing pressure more slowly. This can be achieved by shortening the interval time during the pressure build-up and extending the interval time when the pressure is being reduced, always keeping the pressure build-up and pressure reduction pulses unchanged or by enlarging the pressure build-up pulses and reducing the pressure reduction pulses with unchanged interval times.

According to the invention, the control threshold of the traction-slip control system also is lowered following the detection of a diagonal axle twist.

By lowering the control thresholds of the traction-slip control, the drive slip is reduced additionally. This manipulation of the control threshold, when the off-road

situation of a diagonal axle twist has been detected, preferably occurs only on the wheels that are in an active traction-slip control. Then only the wheels concerned are controlled with small thresholds so as to avoid that stable wheels come into a traction slip control phase.

According to another embodiment of the invention, it is provided that the detected diagnonal axle twist be evaluated as a regulating variable and/or a corresponding control function of the vehicle control system be activated only when the vehicle speed, in particular a calculated or estimated vehicle reference speed, falls below a specified vehicle speed limit value, preferably between 3 to 15 km/h, in particular about 6 km/h. Since a diagonal axle twist basically is a standard situation on bumpy roads and, hence, particularly in off-road driving situations, a center, front axle and/or rear axle differential is locked partially or completely and/or this kind of effect is only executed with means of the traction-slip control system if the vehicle speed is correspondingly low.

According to the invention, a diagonal axle twist of a vehicle with all-wheel drive and a vehicle control system, in particular a traction-slip control system (TCS), is detected by means of a method that is characterized in that the diagonal axle twist is determined on the basis of the wheel slip, rotating behavior and/or changes in rotating behavior of the individual driven wheels.

Within the scope of the invention, the term „vehicles with all-wheel drive„ comprises vehicles where at least four wheels are driven permanently on at least two driven axles and vehicles driven primarily with one axle, where a second axle can be added whenever necessary. This can be done manually or automatically, for example with the help of a viscous transmission unit.

Preferably this method allows the detection of such situations as when an all-wheel drive vehicle drives through a diagonal furrow when driving off-road. By determining the rotating behavior or changes in rotating behavior, it can, in particular, be determined when a diagonally opposite front wheel and rear wheel lose contact to the ground and these two wheels spin.

According to a preferred embodiment of the invention, the rotating behavior of the individual driven wheels is measured and evaluated to determine the traction slip and other regulating variables, and a diagonal axle twist is determined on the basis of a drive slip of the individual wheels grreater than a specified limit value.

According to the invention, it is provided that a diagonal axle twist is determined on the basis of the rotating behavior and/or changes in rotating behavior of at least two transversally opposite wheels as well as two diagonally opposite pairs of wheels.

Within the scope of the invention, the term „transversally opposite wheels„ means that two wheels are transversally opposite one another related to the longitudinal vehicle axis. Thus, it refers to one right wheel and one left wheel of a wheel axle. The term „two diagonally opposite pairs of wheels„ refers to the two wheels located opposite one another along a vehicle diagonal respectively, i.e. the right front wheel and left rear wheel (first vehicle diagonal) or the left front wheel and right rear wheel (second vehicle diagonal).

According to the invention, it is provided that a diagonal axle twist is determined when certain traction slip conditions are fulfilled for a predefined period of time.

According to the invention, a diagonal axle twist is determined when the following conditions are fulfilled for a predefined period of time, i.e. a) a traction slip higher than a specified limit value prevails only on one wheel of the secondary axle; b) a traction slip higher than a specified limit value prevails on both of two diagonally opposite wheels of a pair of wheels; and c) a traction slip lower than a specified limit value prevails on a first wheel of the primary axle, with such first wheel lying opposite a second wheel of the primary axle with a traction slip higher than the specified limit value or at least a lower brake pressure, compared to the second wheel of the primary axle with a traction slip higher than the specified limit value, prevails in the wheel brake of the first wheel of the primary axle, with such first wheel lying opposite the second wheel of the primary axle with a traction slip higher than the specified limit value.

In this context the term „primary axle„ refers to the axle driven first by the engine or in general the axle having a higher drive torque or greater tire contact forces. In addition, the primary axle is characterized in that the wheels of the primary axle, assuming identical driving conditions, enter into a traction slip before the wheels of the secondary axle. The axle which transmits no or only a low drive torque in a state without traction slip is referred to as the „secondary axle„ here. Only when there is a corresponding difference speed will a large drive torque be transmitted by this secondary axle corresponding to the traction-slip control.

According to the invention, the state of a diagonal axle twist is determined when the conditions a) to c) are satisfied for a period of time of 0.3 to 1.5 sec. The exact value can be determined individually by relatively few trials. It depends on the dynamics of the drive train of the respective motor vehicle. In one case, for example, a value of about 0.7 sec. has proven to be particularly suitable.

According to the invention, a diagonal axle twist is determined when the defined traction-slip conditions are satisfied for a relatively short period of time, preferably 50 to 200 msec., in particular about 100 msec., and if the last diagonal axle twist was determined at least several seconds, preferably 5 to 15 sec., in particular about 10 sec., before. In other words, the diagonal axle twist is already detected when the pattern or the conditions of the traction slip is given within a relatively short period of time of, for example, about 100 msec., and when the situation of a diagonal axle twist was already determined before, within a trail time of, for example, about 10 sec.

According to the present invention, it is provided that a traction slip related to the wheel rotation speed of the spinning wheel, between 10 km/h to 40 km/h, preferably about 30 km/h, be specified as traction-slip limit value.

According to another embodiment of the invention, it is also provided that the traction-slip limit value on one wheel be considered exceeded when a control procedure of the traction-slip control system is initiated or maintained at the respective wheel. The traction-slip control system is active when it controls pressure build-up, the holding of the pressure or reduction of pressure at the respective wheel brake.

In connection with the method for controlling a vehicle, in particular a traction-slip control system (TCS), the diagonal axle twist is determined with the help of a method according to one of the Claims 6 to 13. Thus, it is ensured that the diagonal axle twist is definitely detected.

Furthermore, the partial object is solved by means of a circuit arrangement, designed to detect a diagonal axle twist of a motor vehicle with all-wheel drive and a traction-slip control system, with such vehicle exhibiting a detection circuit for

detecting measured changes in the rotating behavior of the driven wheels, wherein the circuit arrangement is characterized in that the circuit arrangement exhibits a first detection circuit for detecting a diagonal axle twist of the vehicle on the basis of the changes in rotating behavior of the driven wheels determined by the detection circuit.

According to an embodiment of the invention, the circuit arrangement is characterized in that the first detection circuit exhibits a first evaluation circuit for evaluating a slip of the wheels on the secondary axle, that the first detection circuit exhibits second and third evaluation circuits for evaluating a slip of the wheels of the two diagonally opposite pairs of wheels respectively, that the first detection circuit exhibits a fourth evaluation circuit for evaluating a slip of the wheels on the primary axle and that the first detection circuit exhibits an integrator and a signal generator to generate a signal when, with the help of the evaluation, certain slip conditions typical for a diagonal axle twist are detected by the first, second, third and fourth evaluation circuits.

According to the invention, it is provided that a second detection circuit be associated with the first detection circuit in order to determine a vehicle reference speed on the basis of measured values, and that the first detection circuit exhibit a comparator to compare the determined vehicle reference speed with a predefined limit value, with the first detection circuit generating a signal indicating a diagonal axle twist only when the determined vehicle reference speed falls below the predefined value.

The invention is to be described in more detail using two flow diagrams (Fig. 1 and Fig. 2) and a block diagram (Fig. 3).

Fig. 1 is a flow diagram of an embodiment of the method according to the invention for detecting slip conditions of a diagonal axle twist in a motor vehicle with a primary front-wheel drive in a traction-slip control cyle.

Fig. 2 is a flow diagram of an embodiment of the method according to the invention for determining a diagonal axle twist after the slip conditions of a diagonal axle twist, in particular according to the sequence shown in Fig. 1, were detected.

Fig. 3 is a block diagram of an embodiment of the circuit arrangement according to the invention for detecting a diagonal axle twist.

At the beginning after the Start (Step 8), in Fig. 1, a low vehicle speed or vehicle reference speed (V_{ref}) lying below a speed threshold (VS) is required as a basic condition for detecting a slip condition of a diagonal axle twist. Since, in the case of a diagonal axle twist, the two wheels in contact with the ground usually do not overspeed, an estimated vehicle reference speed (V_{ref}) corresponds quite well to the actual vehicle speed. In order to avoid unlearning the pattern when starting, preferably a V_{ref} less than 3 to 15 km/h, e.g. less than about 6 km/h, is required. Contrary to the given concrete example of an embodiment (constant value), this speed threshold VS can also be a function of detection safety, because when there is a relatively high pressure level and relatively strong intervention of the traction-slip control, the vehicle speed, as a rule, will be relatively low, causing the above condition to be fulfilled.

In addition, the traction-slip control may only be active on one of the two wheels of the secondary drive axle, i.e. on wheels 3 and 4 of the above-mentioned definition (wheel 1 =

left front, wheel 2 = right front, wheel 3 = right rear, wheel 4 = left rear), which is observed in the following. When the criterion of a low vehicle reference speed (Step 10) is satisfied, this requirement is checked in Step 11 with the query ´TCS at Wheel3 not active or TCS at Wheel4 not active ´.

When condition 11 is satisfied, the query continues to step 12, where the condition ´TCS at Wheel1 active and TCS at Wheel3 active´ (Case A) is checked. If the traction-slip control at Wheel1 and Wheel3 is not active, the corresponding condition ´TCS at Wheel2 active and TCS at Wheel4 active´ (Case B) is checked in a subsequent step 13. Through queries 12 and 13, the occurrence of slip in the diagonally opposite pairs of wheels Wheel1 and Wheel3 in Case A as well as Wheel2 and Wheel4 in Case B are detected.

As far as the wheels of the primary drive axle (Wheel1 and Wheel2) are concerned, traction-slip control should intervene only at the wheel that is diagonal to the controlled wheel of the secondary axle. Hence, the conditions are checked in Step 14 for Case A - corresponding to an TCS controlled Wheel1 - ´TCS at Wheel2 not active´ and in Step 15 - corresponding to an TCS controlled Wheel2 - according to Case B ´TCS at Wheel1 not active´. In certain situations these requirements may not be satisfied, e.g. in the event of a short „loss of contact„ of a wheel having relatively good tire contact, since traction-slip control can occur here for a short time. For this reason, at least a small model pressure is required for the wheel lying opposite the mainly controlled wheel (wheel 1 in Case A and wheel 2 in Case B). The pressure referred to as „model pressure„ here means a pressure calculated for a certain wheel brake.

When the conditions of Steps 9, 11, 12 and 14 in Case A and Steps 9, 11, 13 and 15 in Case B are satisfied, the slip conditions of a diagonal axle twist are given. These are

detected in Step 16; otherwise they will not be detected (Step 17).

The above-mentioned slip conditions or traction-slip control conditions for a diagonal axle twist of a motor vehicle with primary front axle drive can, for example, be detected with the following query:

If ((V_{ref}) < VS)
and a wheel of the secondary axle is not active
and ((TCS active at Wheel1 and TCS active at Wheel3
and ((model pressure Wheel1 >= model pressure Wheel2)
or TCS is not active at Wheel2
)
)
or ((TCS active at Wheel1 and TCS active at Wheel3
and ((model pressure Wheel1 >= model pressure Wheel2)
or TCS is not active at Wheel2.

There result analog relationships for primary rear axle drive, with the pressure conditions and the condition 'TCS not active' applying correspondingly to the wheels of the rear axle (wheels 3 and 4).

Following the detection of the slip conditions of a diagonal axle twist in a traction-slip control cycle (Step 16) shown in Fig. 1, the condition of a diagonal axle twist is determined, preferably according to the flow diagram shown in Fig. 2 (Step 19). When the slip conditions for a diagonal axle twist in a traction-slip control cyle are detected (Step 20), an incorporated first counter (COUNTER1) is incremented by 1 in subsequent Step 22 provided the value of the first counter lies below a certain maximum value ($COUNTER1_{max}$) (Step 21).

If, however, the slip conditions in Step 20 are not satisfied and if the first counter has a value greater than zero (0)

(Step 23), the first counter is decremented by 1 in subsequent Step 24, with such decrementation being continued up to the value zero (0).

These conditions, for example, can be recognized with the following query:

```
If (above condition satisfied)
{
    If (COUNTER1 < COUNTER1max)
       COUNTER1 = COUNTER1 + 1
}
Otherwise (if above condition not satisfied)
{
     If COUNTER1 > 0)
        COUNTER1 = COUNTER1 - 1
```

Following Step 22, Step 25 then checks whether the value of the first counter exceeds a threshold value ($COUNTER1_{lim1}$), with such threshold value lying below the maximum value $COUNTER1_{max}$. If the first counter is greater than the threshold value $COUNTER1_{lim1}$, this means that the above-mentioned conditions were recognized consecutively over a certain period of time, for example 0.3 to 1.5 sec., preferably about 0.7 sec. It is assumed that the situation of a diagonal axle twist was detected (Step 26). Then a signal indicating a diagonal axle twist can be generated, for example, a special control bit can be set; alternatively it can be deleted.

This can be executed with the help of the following query steps:

```
If          COUNTER1 > COUNTER1lim)
            There is diagonal axle twist
Otherwise   (if COUNTER1 < COUNTER1lim1)
            There is no diagonal axle twist
```

Since COUNTER1 can count up to $COUNTER1_{max}$ and the situation above the value $COUNTER1_{lim1}$ is considered to be detected, the mechanism has a „memory„ of $COUNTER1_{max}$ minus $COUNTER1_{lim1}$ multiplied by the cycle time. Another trail effect will occur as a rule because the control phases at the diagonal are maintained longer than the situation of the diagonal axle twist.

In order to avoid this, a second counter (COUNTER2) is set to a start value $COUNTER2_{start}$ (Step 27) when a diagonal axle twist is detected. If a diagonal axle twist is not detected (Step 28) or outside an active traction-slip control, this counter is decremented to the value 0 within a specified time (Step 29). This period of time, for example, may be 10 sec. If the traction-slip control becomes active again due to overspeeding drive wheels within this „trail time„ and if the above-mentioned conditions still prevail (Step 30), then, if COUNTER1 has reached, in comparison to the value $COUNTER1_{lim1}$, a significantly lower value, preferably a value lower by 80 to 90%, $COUNTER1_{lim2}$ (Step 31), the control bit will be set (Step 32). Otherwise the system returns to the main program of the traction-slip control (Step 33). Consequently, the detection time is reduced considerably in this situation, and the above-mentioned disadvantage is avoided.

With the help of the following query, these conditions (COUNTER2) can be detected:

If ((COUNTER2 > 0)
and (slip conditions of a diagonal axle twist detected)
and (TCS active)
Then if (COUNTER1 >= $COUNTER1_{lim2}$)
diagonal twist detected

According to the invention, all steps described above can be realized by means of a program-controlled circuit as

corresponding program steps or through a sub-program within a traction-slip control system.

However, the steps also can be realized with the help of a circuit arrangement. Fig. 3 shows the block diagram of a circuit arrangement which illustrates, by way of example, the essential electric and electronic components of an embodiment designed to detect a diagonal axle twist according to the present invention.

An essential part of the invention is the first detection circuit 40. A first, second, third and fourth evaluation circuit 41, 42, 43, 44 for evaluating a slip of the wheels on the secondary axle (circuit 41), the wheels of the two diagonally opposite pairs of wheels (circuit 42 and 43), and the wheels on the primary axle (circuit 44) are associated with the first detection circuit 40. Inputs 45, 46, 47, 48 of the evaluation circuits 41, 42, 43, 44 are connected to corresponding outputs 49, 50, 51, 52 of a detection circuit 54 for detecting the measured rotating behavior or changes in rotating behavior or traction slip of the individual driven wheels. The first detection circuit 40 also exhibits an integrator 55 and a signal generator 56. When, based on the evaluation of the first, second, third and fourth evaluation circuits, inputs 45, 46, 47, 48 of the evaluation circuits 41, 42, 43, 44 detected typical slip conditions for a diagonal axle twist over a predefined period of time with the help of integrator 55, a signal is generated with the help of signal generator 56 and supplied to an input 58 of a control circuit 59 via an output 57 of the signal generator 56 in order to trigger corresponding traction-slip control intervention. In a preferred embodiment it is provided that a second detection circuit 60 be associated to the first detection circuit 40 for determining a vehicle reference speed on the basis of measured values and that the first detection circuit 40 exhibit a comparator 61, with such comparator 61 exhibiting an input 62

for a signal coming from an output 63 of the second detection circuit 60 for the determined vehicle reference speed. With the help of comparator 61, the determined vehicle reference speed is compared to a predefined limit value. For this purpose, the comparator is connected to an input 65 of the evaluation circuit 41 via an output 64 and, either directly or through circuits not described in detail here, it generates a signal so that the evaluation by the evaluation circuits 41, 42, 43, 44 only occurs if the vehicle reference speed is less than the specified limit value. In this case, the first detection circuit will only generate a signal indicating a diagonal axle twist if the determined vehicle reference speed falls below the specified value, i.e., particularly in connection with a driving situation in „difficult„ terrain at low vehicle speeds.

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Patent Claims

1. Method for controlling a vehicle, in particular a traction-slip control system (TCS), **characterized in that** a diagonal axle twist is detected and evaluated as a regulating variable.

2. Method according to Claim 1, **characterized in that,** following the detection of a diagonal axle twist, the effect of a partial or complete lock of a center, front-axle and/or rear-axle differential is achieved with means of the vehicle control system and/or that a center, front-axle and/or rear-axle differential is locked partially or completely with the help of a differential lock, if such is available.

3. Method according to Claim 1 or 2, **characterized in that,** following the detection of a diagonal axle twist, a medium brake pressure level is set at the wheel brakes of the controlled wheels with a minimum traction slip, corresponding to the required traction, and maintained for a certain period of time.

4. Method according to one of the Claims 1 to 3, **characterized in that,** following the detection of a diagonal axle twist, the control threshold of the traction-slip control system is additionally reduced.

5. Method according to one of the Claim 1 to 4, **characterized in that** the detected diagonal axle twist is evaluated as a regulating variable and/or a corresponding control function of the vehicle control system is only activated when the vehicle speed, in particular a calculated or estimated vehicle reference speed, falls below a specificed vehicle speed limit value, preferably within the range of 3 to 15 km/h.

6. Method for detecting a diagonal axle twist of a motor vehicle with all-wheel drive and a vehicle control system, in particular a traction-slip control system system, **characterized in that** the diagonal axle twist is determined on the basis of the wheel slip, the rotating behavior and/or changes in rotating behavior of the individual, driven wheels.

7. Method for detecting a diagonal axle twist according to Claim 6, **characterized in that** the rotating behavior of the individual, driven wheels is measured and evaluated to determine the traction slip and other regulating variables and that a diagonal axle twist is determined on the basis of a traction slip of the individual wheels that is greater than a specified limit value.

8. Method according to Claim 6 or 7, **characterized in that** a diagonal axle twist is determined on the basis of the rotating behavior and/or changes in rotating behavior of at least two transversally opposite wheels as well as two diagonally opposite pairs of wheels respectively.

9. Method according to Claim 7 or 8, **characterized in that** a diagonal axle twist is determined when certain traction-slip conditions are satisfied for a certain period of time.

10. Method according to Claim 9, **characterized in that** a diagonal axle twist is detected when the following conditions are satisfied for a predefined period of time:

a) a traction slip greater than a specified limit value prevails only on one wheel of the secondary axle;

b) a traction slip greater than the specified limit value prevails on both of two diagonally opposite wheels of a pair of wheels, and

c) a traction slip less than the specified limit value prevails on a first wheel of the primary axle, with such first wheel lying opposite a second wheel of the primary axle with a traction slip greater than the specified limit value or that at least a low brake pressure, compared to the second wheel of the primary axle with a traction slip greater than the specified limit value, is given in the wheel brake of the first wheel of the primary axle, with such first wheel lying opposite the second wheel of the primary axle with a traction slip greater than the specified limit value.

11. Method according to Claim 10, **characterized in that** the state of a diagonal axle twist is determined when conditions a) to c) are satisfied for a period of time of 0.3 to 1.5 sec.

12. Method according to one of the Claims 9 to 11, **characterized in that**, a diagnonal axle twist is determined when the specified traction-slip conditions are satisfied for a relatively short period of time, preferably 50 to 200 msec., and if the last previous diagonal axle twist was determined just a few seconds before, preferably 5 to 15 sec.

13. Method according to one of the Claims 8 to 12, **characterized in that** a traction slip, related to the wheel rotation speed of the spinning wheel, is specified as the traction-slip limit value within a range of 10 km/h to 40 km/h.

14. Method according to one of the Claims 8 to 13, **characterized in that** the traction-slip limit value on a

wheel is considered to have been exceeded when a control procedure of the traction-slip control system is activated or continued at the respective wheel.

15. Method for controlling a motor vehicle, in particular a traction-slip control system (TCS), **characterized in that** the diagonal axle twist is detected with the help of a method according to one of the Claims 6 to 14.

16. Circuit arrangement for detecting a diagonal axle twist of a motor vehicle with all-wheel drive and a traction-slip control system, with such motor vehicle exhibiting a detection circuit for detecting measured changes in rotating behavior of the driven wheels, **characterized in that** the circuit arrangement exhibits a first detection circuit (40) for detecting a diagonal axle twist of the motor vehicle on the basis of the changes in rotating behavior of the driven wheels detected by the detection circuit (54).

17. Circuit arrangement according to Claim 16, **characterized in that** the first detection circuit (40) exhibits a first evaluating circuit (41) for evaluating a slip of the wheels on the secondary axle, that the first detection circuit (40) exhibits a second and third evaluation circuit (42, 43) for evaluating a slip of the wheels of the two diagonally opposite pairs of wheels respectively, that the first detection circuit (40) exhibits a fourth evaluation circuit (44) for evaluating a slip of the wheels on the primary axle and that the first detection circuit (40) exhibits an integrator (55) and a signal generator (56) for generating a signal when slip conditions typical for a diagonal axle twist were detected over a certain period of time with the help of the evaluation of the first, second, third and fourth evaluating circuits (41, 42, 43, 44).

18. Circuit arrangement according to Claim 16 or 17, **characterized in that** a second detection circuit (60) is associated with the first detection circuit (40) for detecting a vehicle reference speed on the basis of measured values and that the first detection circuit (40) exhibits a comparator (61) for comparing the determined vehicle reference speed with a specified limit value, with the first detection circuit (40) generating a signal indicating a diagonal axle twist only if the determined vehicle reference speed falls below the specified value.

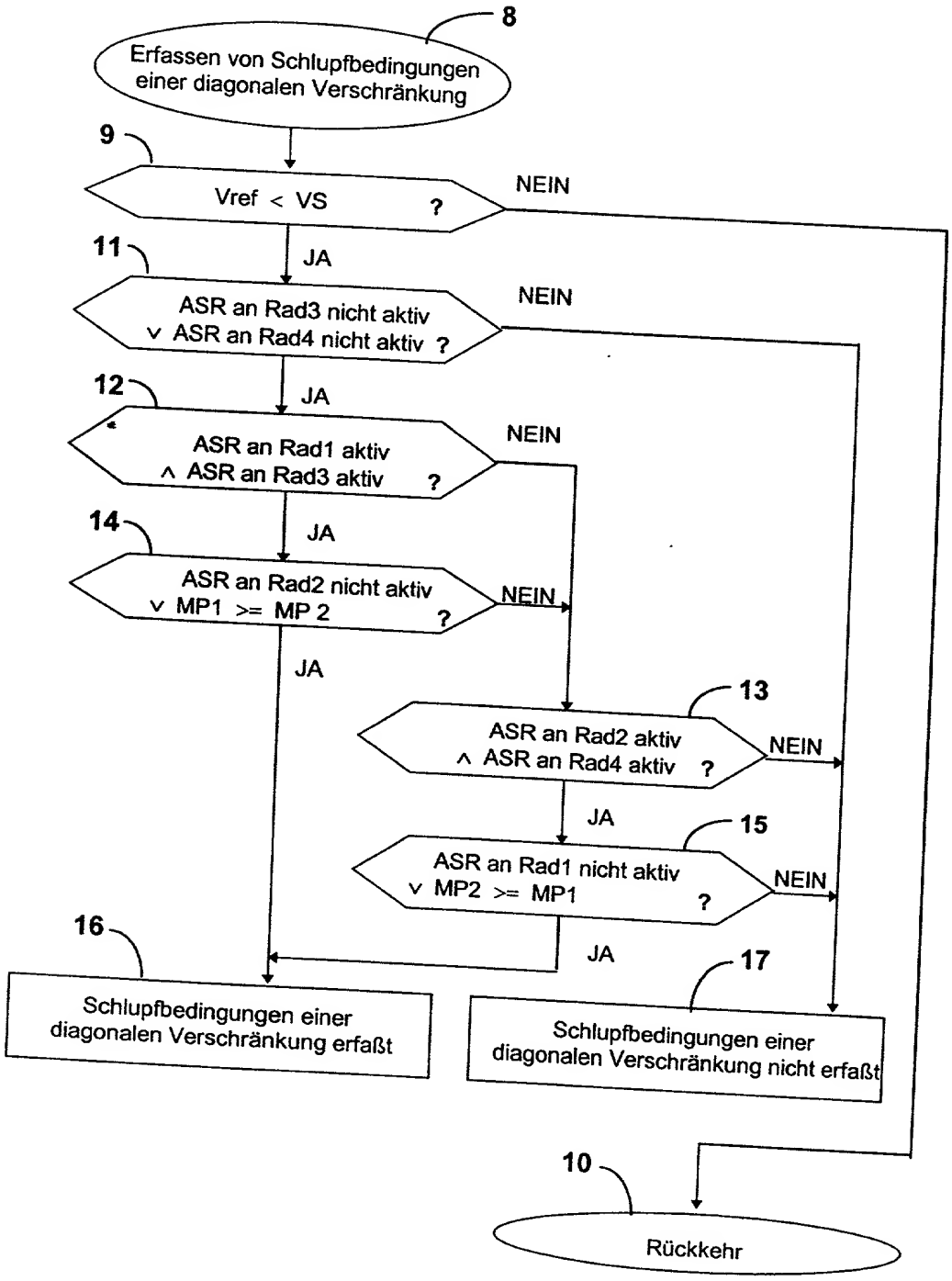
8
Erfassen von Schlupfbedingungen einer diagonalen Verschränkung
9
Vref < VS ?
NEIN
JA
11
ASR an Rad3 nicht aktiv
v ASR an Rad4 nicht aktiv ?
NEIN
JA
12
ASR an Rad1 aktiv
^ ASR an Rad3 aktiv ?
NEIN
JA
14
ASR an Rad2 nicht aktiv
v MP1 >= MP 2 ?
NEIN
JA
13
ASR an Rad2 aktiv
^ ASR an Rad4 aktiv ?
NEIN
JA
15
ASR an Rad1 nicht aktiv
v MP2 >= MP1 ?
NEIN
JA
16
Schlupfbedingungen einer diagonalen Verschränkung erfaßt
17
Schlupfbedingungen einer diagonalen Verschränkung nicht erfaßt
10
Rückkehr

Fig. 1

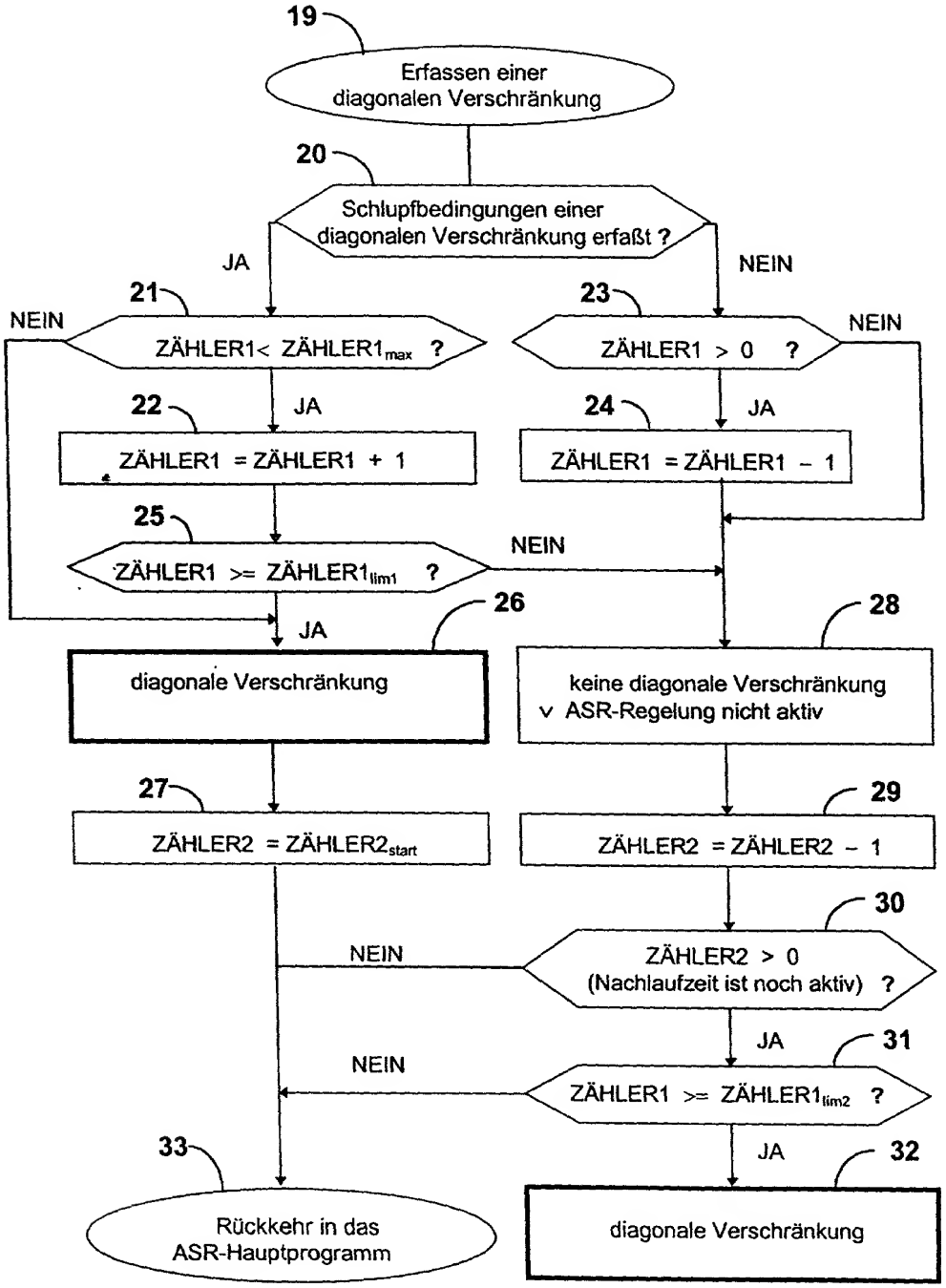
19
Erfassen einer diagonalen Verschränkung
20
Schlupfbedingungen einer diagonalen Verschränkung erfaßt ?
JA
NEIN
21
NEIN
ZÄHLER1< ZÄHLER1max ?
23
ZÄHLER1 > 0 ?
NEIN
22
JA
ZÄHLER1 = ZÄHLER1 + 1
24
JA
ZÄHLER1 = ZÄHLER1 – 1
25
ZÄHLER1 >= ZÄHLER1lim1 ?
NEIN
JA
26
diagonale Verschränkung
28
keine diagonale Verschränkung
v ASR-Regelung nicht aktiv
27
ZÄHLER2 = ZÄHLER2start
29
ZÄHLER2 = ZÄHLER2 – 1
30
NEIN
ZÄHLER2 > 0
(Nachlaufzeit ist noch aktiv) ?
JA
31
NEIN
ZÄHLER1 >= ZÄHLER1lim2 ?
JA
32
33
Rückkehr in das ASR-Hauptprogramm
diagonale Verschränkung

Fig. 2

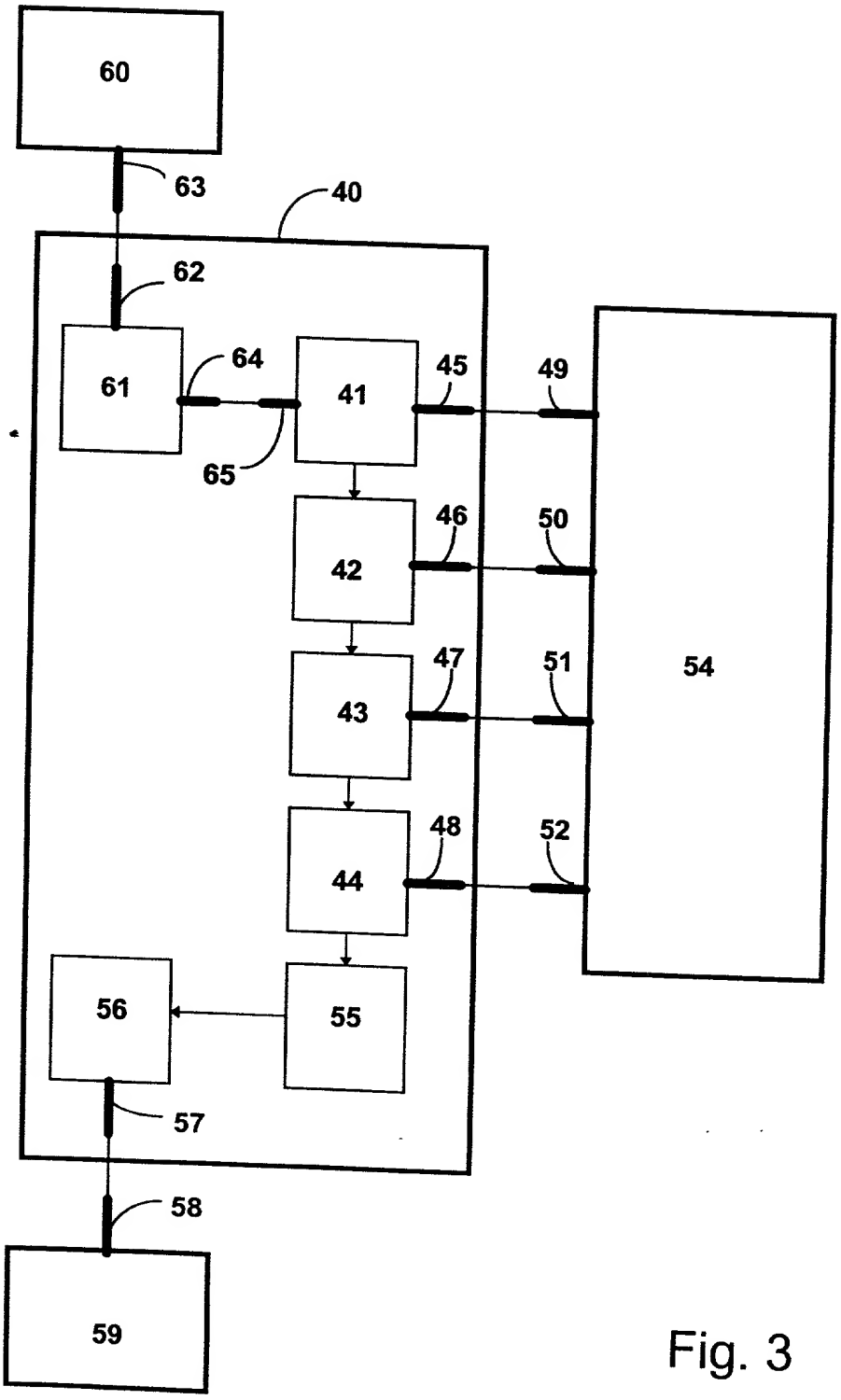

Fig. 3

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OIPE JC164
FEB 19 2002
PATENT & TRADEMARK OFFICE

Declaration and Power of Attorney for Patent Application

Erklärung für Patentanmeldungen mit Vollmacht

German Language Declaration

Als nachstehend benannter Erfinder erklare ich hiermit an Eides Statt·

As a below named inventor, I hereby declare that:

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My residence, post office address and citzenship are as stated next to my name.

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I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

Method for Controlling a Motor Vehicle

deren Beschreibung hier beigefügt ist, es sei denn (in diesem Falle Zutreffendes bitte ankreuzen), diese Erfindung

the specification of which is attached hereto unless the following box is checked:

wurde angemeldet am _____, unter der US-Anmeldenummer order unter der Internationalen Anmeldenummer im Rahmen des Vertrags uber die Zusammenarbeit auf dem Gebiet des Patentwesens (PCT) _____ und am _____ abgeandert (falls zutreffend).

was filed on August 30, 2001, using Express Mailing (Label No.EJ881125800US) as United States Application Number or PCT International Application Number _____ and was amended on _____ (if applicable).

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Ich beanspruche hiermit ausländische Prioritätsvorteile gemäß Title 35, US-Code, § 119 (a)-(d), bzw. § 365(b) aller unten aufgefuhrten Auslandsanmeldungen fur Patente oder Erfinderurkunden, oder § 365(a) aller PCT internationalen Anmeldungen, welche wenigstens ein Land ausser den Vereinigten Staaten von Amerika benennen, und habe nachstehend durch ankreuzen samtliche Auslandsanmeldungen fur Patente bzw Erfinderurkunden oder PCT internationale Anmeldungen angegeben, deren Anmeldetag dem der Anmeldung, fur welche Prioritat beansprucht wird, vorangeht.

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Prior Foreign Applications (Fruhere ausländische Anmeldungen)		Priority Not Claimed Priorität nicht beanspruct
199 09 454 3	Germany	04 March 1999 (04.03.99)
(Number) (Nummer)	(Country) (Land)	(Day/Month/Year Filed) (Tag/Monat/Jahr der Anmeldung)
199 53 773 9	Germany	09 November 1999 (09.11.99)
(Number) (Nummer)	(Country) (Land)	(Day/Month/Year Filed) (Tag/Monat/Jahr der Anmeldung)

Ich beanspruche hiermit die mir unter Title 35, US-Code, § 120 zustehenden Vorteile aller unten aufgeführten US-Patentanmeldungen bzw. § 365(c) aller PCT internationalen Anmeldungen, welche die Vereinigten Staaten von Amerika benennen, und erkenne, insofern der Gegenstand eines jeden fruheren Anspruchs dieser Patentanmeldung nicht in einer US-Patentanmeldung, bzw. PCT internationalen Anmeldung in in einer gemaß dem ersten Absatz von Title 35, US-Code, § 112 vorgeschriebenen Art und Weise offenbart wurde, meine Pflicht zur Offenbarung jeglicher Informationen an, die zur Prüfung der Patentfahigkeit in Einklang mit Title 37, Code of Federal Regulations, § 1.56 von Belang sind und die im Zeitraum zwischen dem Anmeldetag der früheren Patentanmeldung und dem nationalen oder im Rahmen des Vertrags uber die Zusammenarbeit auf dem Gebiet des Patentwesen (PCT) gultigen internationalen Anmeldetags bekannt geworden sind.

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PCT/EP00/01657	28 February 2000	Pending
(Application No) (Aktenzeichen)	(Filing Date) (Anmeldetag)	(Status) (patented, pending, abandoned) (Status) (patentiert, schwebend, aufgegeben)
(Application No.) (Aktenzeichen)	(Filing Date) (Anmeldetag)	(Status) (patented, pending, abandoned) (Status) (patentiert, schwebend, aufgegeben)

Ich erkläre hiermit, daß alle in der vorliegenden Erklarung von mir gemachten Angaben nach bestem Wissen und Gewissen der Wahrheit enstprechen, und ferner daß ich diese eidesstattliche Erklärung in Kenntnis dessen ablege, daß wissentlich und vorsatzlich falsche Angaben oder dergleichen gemaß § 1001, Title 18 des US-Code strafbar sind und mit Geldstrafe und/oder Gefangnis bestraft werden können und daß derartige wissentlich und vorsatzlich falsche Angaben die Rechtswirksamkeit der vorliegenden Patentanmeldung oder eines aufgrund deren erteilten Patentes gefährden konnen

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POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith: Steven L. Oberholtzer, Reg. No. 30,670 and each shareholder, attorney of counsel and associate of Brinks Hofer Gilson & Lione who is a registered Patent Attorney

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(Supply similar information and signature for seventh and subsequent joint inventors.)